SECTION E.

Mr. Sowerbutts said that the Manchester Geographical Society had come to the conclusion that geography would never be taught satisfactorily in primary schools unless it was made a compulsory subject. Progress had been made in some primary schools by the institution of school-museums. It was a singular fact that at an examination in geography of the primary schools of Cheshire, Lancashire, and Yorkshire, the girls had won all the prizes in Yorkshire, and the boys in Lancashire. His Society had for the last two or three years published an analysis of the chief geographical papers which had appeared in English and foreign journals.

SECTION H.

Ethnographical Survey.—Mr. Brabrook remarked that during the past year their list of suitable villages had been considerably increased, and now numbered 367. At Ipswich a sub-committee had been formed to assist them, and at Liverpool the keeper of the museum had given most valuable help. In Wales their sub-committee had met and had done good work, and the same remark might be made of Ireland. In Scotland they had a promise of assistance from the Glasgow Archæological Society. They had been told that their instructions about photographing were too minute, but they had been drawn up by Mr. Francis Galton with reference to his system of composite photographs, and any departure from them would make the application of that system comparatively difficult.

Mr. Sowerbutts stated that old people in his district objected to be photographed and measured.

Dr. Garson said that as regards photographs it was not necessary to get all the appliances Mr. Galton had mentioned. It was desirable to have a seat which could be raised or lowered like a piano-stool, so that each person might have his head in the same place, whatever his height might be. It was well, also, to have chalk lines on the floor at right angles to each other, the sitter being directed to look along either one line or the other. They did not want measurements of people more than fifty years old.

Mr. Brabrook added that a set of instruments for measurements might be had for £1 6s., and a more expensive set for £3 3s. And Dr. Garson remarked that the cheaper set was quite good enough.

A vote of thanks to the chairman closed the proceedings.

SCIENTIFIC SERIALS.

Proceedings of the Edinburgh Mathematical Society, vol. xii. (Williams and Norgate, 1894.)—The geometrography of Euclid's problems, by Dr. J. S. Mackay, is a modification of M. E. Lemoine's La Géométrographie ou l'art des constructions Géométriques (the subject of two memoirs read at the Oran (1888) and Pau (1892) meetings of the French Association for the Advancement of the Sciences), and an application of it to the problems in the first six books of Euclid's "Elements." The restrictions are those of Euclid, viz. that the constructions should be effected by means of the straight-edge and compasses only. It is an interesting introduction of M. Lemoine's methods to English readers. The same author contributes formulæ connected with the radii of the incircle and the excircles of a triangle. This is on the lines of the work we recently noticed by the same writer (vol. i. *Edin. Math. Soc. Proceedings*). It is founded upon a table given in the *Lady's and Gentleman's Diary* for 1871. Nearly all of the eighty formulæ are assigned to the authors who first published them: possibly those unassigned are due to Dr. Mackay himself. M. Paul Aubert, in his "Coordonnées Tangentielles," applies them to the discussion of a number of general problems relating to surfaces of the second order.—Dr. Sprague writes on the geometrical interpretation of i^i; his investigation was suggested by a result given in Hayward's "Vector Algebra and Trigonometry."—Mr. G. A. Gibson, in a proof of the uniform convergence of the Fourier Series, with notes on the differentiation of the series, discusses a point which has not, apparently, been considered in the English text-books.—In addition to the above papers there are several short notes: Prof. Crum Brown gives an abstract of a paper (to appear) in the *Transactions* of the Royal Society of Edinburgh, on the division of a parallelepiped into tetrahedra; notes on factoring, J. W. Butters; on a problem in tangency, G. E. Crawford; on certain maxima and minima, G. Duthie; on solutions of certain differential equations, F. H. Jackson; on E. Carpenter's proof of Taylor's theorem, R. F. Muirhead; notes on the number of numbers less than a given number and prime to it, and on the pedal triangle, Prof. Steggall; five notes, viz. two circular notes, geometrical note (ii.), two triplets of circum-hyperbolas, three parabolas connected with a plane triangle, and notes on an orthocentric triangle, R. Tucker; and a note, by W. Wallace, on a third mode of section of the straight line. Of the other communications that were made to the Society during the session the titles only are given. A list of members and of the presents made to the library close the volume, which contains a good deal of matter of interest to mathematical teachers.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 7.—"On the Recurrent Images following Visual Impressions." By Shelford Bidwell, F.R.S.

The earliest recorded observation of a certain curious phenomenon associated with optical after-images is that of Prof. C. A. Young, who published a note on the subject in the year 1872, and proposed that the phenomena should be called "recurrent vision." (*Phil. Mag.* vol. xliii. 1872, p. 343). He noticed that when a powerful Leyden jar discharge took place in a darkened room, any conspicuous object was seen twice at least, with an interval of a little less than a quarter of a second; often it was seen a third time, and sometimes even a fourth.

A few months later an account of two experiments on the same subject was published by Mr. A. S. Davis. (*Phil. Mag.* vol. xliv. 1872, p. 526). In the first, a piece of charcoal, one end of which was red-hot, was waved about so as to describe an ellipse or circle a few inches in diameter. A blue image of the burning end was seen following the charcoal at a short distance behind it, the space between the charcoal and its image being absolutely dark. The other experiment was made with a piece of apparatus resembling a photographic instantaneous shutter. The shutter was interposed between the observer's eye and the sky, and was covered with pieces of coloured glass, through which momentary flashes of light were allowed to pass. It was found that each flash was, after a short interval, generally succeeded by a recurrent image, the colour of which was nearly complementary to that of the glass.

In 1885 the author called attention to a very simple and effective method of exhibiting a recurrent image (NATURE, vol. xxxii. 1885, p. 30). If an ordinary vacuum tube, illuminated by an induction coil discharge, is made to rotate slowly upon a horizontal axis fixed at right angles to the middle of the tube, the tube is seen to be followed at a distance of a few degrees by a ghost-like image of itself, the ghost exactly imitating the original in form, but having a uniform steel-grey colour. In the same paper the following observation is noted:—"The vacuum tube being at rest in a feebly lighted room, I concentrated my gaze upon a certain small portion of it while the discharge was passing. The current was then interrupted, and the luminous image was almost instantly replaced by a corresponding image which appeared to be intensely black upon a less dark background. After a period, which I estimated at from a quarter to half a second, the black image again became luminous; this luminous impression lasted but for a small fraction of a second, and the series of phenomena terminated with its disappearance. . . . It was also found desirable to make the preliminary illumination as short as possible, a single flash being generally sufficient to produce the phenomena." The following comment was added:—"The series of phenomena seem to be due to an affection of the optic nerve which is of an oscillatory character. Abnormal darkness follows as a reaction after the luminosity, and again after abnormal darkness there is a rebound into feebler luminosity."

The subject has recently attracted much attention in connection with the experiments of M. Aug. Charpentier. The account of them given by M. Charpentier in a paper on "Retinal Oscillations"[1] is briefly as follows:—If a black disk having a white sector is illuminated by a strong light, and slowly turned round while the observer's eye is fixed upon its centre, there appears upon the white sector, near to its leading edge, a well-defined dark band, which is separated from the black ground of the disk by a similar white band. The angular extension of the dark band increases with the speed of rotation, so that it always takes the same time to pass over a fixed point on the retina; it begins about one-sixty-fifth or one-seventieth of a second after the first passage of the white, and lasts sensibly the same time. He goes on:—"The dark band is in fact only a kind of reaction of the retina after the luminous excitation, a reaction which can be demonstrated in a totally different manner. I have found that if an instantaneous luminous excitation is produced in complete darkness the sensation appears to be reduplicated; shortly after its first generation it seems to disappear, and then manifest itself again. This is the case, for example, when a single discharge from a Ruhmkorff coil is passed through a Crookes or Geissler vacuum tube, or simply, but less obviously, through the air. . . . . There is, then, in this last experiment, as in the first, a negative reaction of the retina under the influence of excitation. . . . . It would be difficult, and in any case premature, to indicate the cause of this phenomenon, but it may fairly be characterised as the result of a retinal oscillation set up under the influence of the beginning of the luminous excitation."

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[1] "Oscillations rétiniennes," *Comptes Rendus*, vol. cxiii. 1891, p. 147. See also "Réaction oscillatoire de la Rétine," *Arch. de Physiologie*, 1892, p. 541.

The present paper deals partly with the colours of recurrent images under different conditions, and partly with the reaction attending the early stages of a luminous impression as noticed by Charpentier.

In the observation of the recurrent images set up by the action of light of different colours, the author began, like Mr. Davis, by using coloured glasses.

A metal disk, about 8 cm. in diameter, was arranged so as to rotate slowly and steadily about its centre in front of the condenser of a projection lantern. Near the edge of the disk was a circular aperture about 0·5 cm. in diameter, the image of which was focussed upon a distant screen. A plate of coloured glass was placed before the projecting lens, and thus was obtained a small coloured disk of light, which described a circular path upon the screen. The coloured disk was, in most cases, seen to be followed at an interval of a few degrees by a ghost of the same size and shape, but of feebler luminosity, and of a hue which varied more or less with the colour of the glass employed. With white electric light the colour of the ghost was violet.

This method of experimenting was, however, found to be unsuited for the purpose in view, and it is mentioned only on account of the facility which it affords for exhibiting the phenomenon to a large number of persons. To obtain results of any value, it was necessary to employ the simple colours of the spectrum.

In the arrangement finally adopted, light from a selected portion of a spectrum was projected upon a small mirror, to the back of which was attached a horizontal arm, not quite perpendicular to the mirror: the arm was rotated by clockwork, and the reflected beam of light was received upon a white screen, forming a coloured disk about 1·5 cm. in diameter, which revolved in a circular path having a diameter of 30 cm.

When the mirror turned once in 1½ seconds the ghost or recurrent image appeared about 50° behind the coloured disk, the corresponding time interval being one-fifth of a second. The ghost appeared to be circular in form, its diameter being generally rather less than that of the original. The colours of the recurrent images, as specified below, have all been observed by several persons, and, except as to those at the extreme limits of visibility, all the observations were in agreement.

Spectrum colours.	Recurrent colours.
Extreme violet... ...	No perceptible image.
Middle violet	A pale image, variously described as grey, yellow, and greenish-yellow.
Dark blue	Feeble violet.
Light blue	Brighter violet.
Middle green	Bright violet. The image is more conspicuous with green light than with any other.
Greenish-yellow ...	Blue.
Orange-yellow... ...	Bluish-green.
Orange	Dark bluish-green.
Orange-red	Very dark bluish-green.
Red	No image at all, however bright the red was made.

A complete small spectrum, revolving parallel to itself in a circle about 1 metre in diameter, was followed by a ghost which corresponded to the portion of the spectrum comprised between the orange and the beginning of the violet. The *whole* of this ghost was of a violet hue: no trace whatever of yellow or greenish-yellow could be detected at the more refrangible end, nor of blue or bluish-green at the other.

From other experiments it appeared probable that the blue and bluish-green recurrent colours apparently observed when the yellow and orange portions of the spectrum are tested separately are due merely to an effect of mental judgment, and not to any cause of a physiological nature.

Four independent facts are consistent with the conclusion that luminous recurrent images are due to a reaction of the *violet* nerve fibres only.

(*a*) With white light the recurrent colour is violet.

(*b*) In the recurrent image of the complete spectrum no colour but violet can be detected.

(*c*) A pure red light, however intense, gives no recurrent image. (It is generally supposed by the supporters of the Young-Helmholtz theory that red light has no action upon the violet nerve-fibres.)

(*d*) The apparently blue colour of the ghost of simple spectrum yellow is just as well produced by a compound yellow consisting of green and red, the latter of which is inert when tested separately.

The path of the revolving spot of light is generally marked by a phosphorescent track, which, when the rate of revolution is not less than one turn in 1½ seconds, often forms a complete circle. The trail is due to the usually feeble continuation of the after-image, of which the bright initial stage constitutes the recurrent image.

In the experiment next to be described, the Charpentier effect and the recurrent image are made to exhibit themselves simultaneously.

Two blackened zinc disks, 15 cm. in diameter, from each of which two opposite quadrants were cut out, were mounted in contact with each other on a horizontal axis, driven by clockwork, and making one turn in 1½ seconds. By slipping the disks over one another round their centres, opposite open sectors might be obtained, of any aperture from 0° to 90°. The apparatus was set up opposite a box containing a 32-candle power incandescent lamp, with a variable resistance in the circuit, the side of the box between the lamp and the disks being covered with a sheet of ground glass.

The sectors being in the first place opened as widely as possible, Charpentier's dark band was easily seen upon the illuminated background.

The sectors were then gradually closed up, until the posterior edge of the dark band approximately coincided with that of the sector. When this was accomplished, it was found that the arc of the open sector was equal to about $\frac{1}{52}$ part of the whole circumference. The dark reaction, therefore, ceased in ($\frac{1}{52}$ of 1½ seconds =) $\frac{1}{35}$ second after the first impact of the light upon the eye.

For more readily demonstrating the succeeding phenomena, it was found convenient to again open the sectors a little, so that they covered an angle of about 10° or 12°. Resuming the observation, it was seen that the posterior edge of the open sector was bordered by a luminous fringe due to persistence. A little beyond the termination of the fringe there appeared an intensely black radial band, estimated to cover a space of from 3° to 4°, and distinguishable even upon the black ground of the metal disk, though it is shown far more conspicuously upon a translucent disk made of stout writing-paper with a sector cut out. Lastly, after another interval of perhaps 35° or 40°, came the luminous recurrent image, which, with the yellowish light of the incandescent lamp, appeared to be of a blue colour.

This method of observation revealed one other point of interest, which seems hitherto to have escaped notice, though it is evident enough with a Charpentier disk, when once attention has been directed to it. The average illumination of the bright band intervening between the dark band and the leading edge of the sector is much more intense than that of the other portion of the sector. Moreover, it is not uniform, but increases, gradually at first, and very rapidly at last, from the leading edge up to the dark band. In fact when the light used is not strong, the luminous margin of the bright band is a far more conspicuous object than the dark band itself: it appears to glow almost like a white-hot wire.

Charpentier states that, under favourable conditions, he has been able to detect the existence of a second, and even of a third, dark band of greatly diminished intensity, though he adds that the observation is a very difficult one. What is probably the same effect in a different form can, however, be shown quite easily in the following manner:—

In a blackened zinc disk 15 cm. in diameter, there were cut two opposite radial slits, about 0·5 mm. in width. The disk was rotated at the rate of one turn per second in front of a sheet of ground glass, behind which was an incandescent lamp. The glass was covered with opaque paper, in which a circular opening was made of slightly less diameter than the disk. The disk was placed opposite this opening, and no light reached the eye except such as passed through the two slits. When the disk was observed from a distance of about 1½ metres, the eye being fixed upon its centre, each slit appeared to give four (or possibly five) luminous images, arranged like the ribs of a partly opened fan. The images were distinctly separated by dark intervals near the circumference, but overlapped one another towards the centre. The leading image was naturally the brightest, each consecutive image being considerably weaker than its precursor. All had the same tone of colour, namely, that of the yellowish-light given by the electric lamp. The usual blue recurrent image could also be seen following the images of the radial slits, at an angle of about 80°.

It appears, then, that when the retina is exposed to the action of light for a limited time, the complete order of visual phenomena is as follows:—

(1) Immediately upon the impact of the light there is experienced a sensation of luminosity, the intensity of which increases for about one-sixtieth of a second: more rapidly towards the end of that period than at first.

(2) Then ensues a sudden reaction, lasting also for about one-sixtieth of a second, in virtue of which the retina becomes partially insensible to renewed or continued luminous impressions. These two effects may be repeated in a diminished degree, as often as three or four times.

(3) The stage of fluctuation is succeeded by a sensation of steady luminosity, the intensity of which is, however, considerably below the mean of that experienced during the first one-sixtieth of a second.

(4) After the external light has been shut off, a sensation of diminishing luminosity continues for a short time, and is succeeded by a brief interval of darkness.

(5) Then follows a sudden and clearly-defined sensation of what may be called abnormal darkness—darker than common darkness—which lasts for about one-sixtieth of a second, and is followed by another interval of ordinary darkness.

(6) Finally, in about a fifth of a second after the extinction of the external light, there occurs another transient impression of luminosity, generally violet coloured, after which the uniformity of the darkness remains undisturbed.

No account has been taken of the comparatively feeble after-image, to which the phosphorescent trail before referred to is due, and which may last for two seconds or more.

In an addendum to the paper reference is made to the recent experiments of Dr. Carl Hess ("Pflüger's Archiv für Physiologie," vol. xlix. p. 190).

Paris.

Academy of Sciences, August 27.—M. Lœwy in the chair.—On the variations of the apparent signs of lines and angles, in direct vision and in vision by movements of the eyes and head, by M. Ch. Henry. Formulæ and tables are given embodying the results of the consideration of a great number of cases and enabling apparent sizes to be calculated.—On the transformation of *équations canoniques* in the problem of three bodies, by M. Paul Vernier.—On the possibility of replacing the indeterminate problem given by the generalisation of Pascal's theorem by a determinate problem, by M. Paul Serret.—Researches on the movements of the solar atmosphere, by M. H. Deslandres. An examination of many photographs of spectra of the sun reveals interesting phenomena in connection with a bright line occurring within the wide dark lines H and K of calcium. This line may be resolved into two bright lines enclosing a dark line; the bright lines correspond to the lower layers of the chromosphere, while the dark line belongs to the higher layers. These bright lines often show dissymmetry, sometimes one and sometimes the other becoming the narrower. Spectra of the faculæ do not usually show this dissymmetry, but it is a common condition over the remainder of the surface, and is more pronounced near the equator than in the neighbourhood of the poles. Near spots the observed dissymmetry is often in the opposite direction on opposite sides, and the narrowing of the line is sometimes irregular. These phenomena can be explained on the hypothesis of a continual circulation of the sun's atmosphere, but it is worth noting that a less marked dissymmetry has been obtained in the calcium spectrum produced by the induction spark. Resemblances are pointed out between these phenomena and those observed in the spectrum of Nova Aurigæ.—A remarkable thunderstorm, by M. Ch. V. Zenger.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Books.—Fabrication de la Fonte: E. de Billy (Paris, Gauthier-Villars).—City and Guilds of London Institute, Programme of Technological Examinations, &c., Session 1894-95 (Whittaker).—Review of Mineral Production in India for 1893 (Calcutta).—Sach-und Orts-Verzeichnis zu den Mineralogischen und Geologischen Arbeiten von Gerhard vom Rath: W. Bruhns and K. Busz (Leipzig, Engelmann).—Katalog der Bibliothek der Kaiserlichen Leopoldinisch-Carolinischen Deutschen Akademie der Naturforscher, Fünfte Liefg. Band 22: O. Grulich (Halle, Blochmann).—The Country Month by Month, September, Owen and Boulger (Bliss).

Pamphlets.—Tellustria: B. G. Jenkins (Norwood, Morgan).—Manchester Microscopical Society Transactions and Annual Report, 1893 (Manchester).

Serials.—Zeitschrift für Wissenschaftliche Zoologie, lviii. Band, 1 and 2 Heft (Leipzig, Engelmann).—Natural History of Plants, Part 5: Kerner and Oliver (Blackie).—Contemporary Review, September (Isbister).—Scribner's Magazine, September (S. Low).—Journal of the Chemical Society, September (Gurney).—National Review, September (Allen).—Journal of the Asiatic Society of Bengal, Vol. lxiii. Part 2, No. 1: Part 3, No. 1 (Calcutta).—Himmel und Erde, September (Berlin).—Fortnightly Review, September (Chapman).

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